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AGRICULTURAL MEMORANDUM 446

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The filling and maturing of barley grain in relation to the weather

Previously, the period from ear emergence to dead ripeness was treated as one unit. This time can be divided into three periods:

1. 15-20 days after fertilization. Rapid swelling of the grain occurs as sugars are translocated to the grain.

2. Next 6-9 days. The sugars are converted to insoluble polysaccharide storage products (eg starch). This corresponds to the milky ripe stage of maturity and dry matter accumulation normally ceases at the end of this stage.

3. The final stage of maturation involves the loss of water from the grain. Initially the grain moisture content may be 90% (dry basis), but this decreases until the grain is fit to combine at the stage of dead ripeness (20% or below).

Possible Weather Factors

Stage 1. There is controversy about this stage as to whether the rate of grain growth is limited by the "sink size" of the ear, or by the supply of carbohydrates from the photosynthesising parts. The former hypothesis regards grain swelling as a response to gibberellin synthesis by the seed while the latter depends upon the net photosynthesis during filling which is a function of light, leaf area etc.

Little is known about gibberellin synthesis under field conditions except that long days favour high hormone levels generally. It is assumed that the demand for carbohydrates, which is hormonally induced, never exceeds the supply. This implies some degree of weather independence.

If, on the other hand, the carbohydrate supply was limiting the growth then this would depend upon the weather during filling (light, temperature), and upon the previous weather (leaf area).

Stage 2. This stage is of relatively shorter duration than the others and since no milk ripe dates were available it was ignored.

Stage 3. The loss of water from grain can be represented by,

$$\ln x_0 - \ln x_f = AdE \qquad (1)$$

x_0 is the initial grain moisture content (dry basis)

x_f is the final grain moisture content (dry basis)

A is a factor which is constant for a given quantity of grain

d is the duration of drying

E is the energy supplied for drying the grain averaged over time d.

For standing grain in the field E is assumed to be potential transpiration P. Equation (1) is only applicable when no rain falls, but should at least be a starting point.

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Severe dehydration can stop the course of ripening at any stage. Even moderate water stress during filling can reduce photosynthesis and initiate biochemical changes leading to maturity (Williams 1970).

Correlations

If x_o, x_f and A are assumed constant, then equation (1) shows that d should be correlated with 1/P (P is the mean daily potential transpiration during the estimated period of grain drying). Also if the filling time is constant for the different barley trials then the total time D between ear emergence and dead ripeness should also be correlated with 1/P. Using the E.B.C. data from 63 trials, the linear correlation between D and 1/P was +0.827. A similar correlation between D and $1/P^1$ (where P^1 is the potential transpiration during the estimated period of grain filling) was +0.655. These results suggest that there is an indication of a greater weather dependence in the final stages of grain ripening.

This analysis does not satisfactorily explain the relatively faster ripening in Finland and slower ripening in Portugal. This was thought to be due to the inadequate assumption of one value in all countries for x_f (corresponding to dead ripeness). The trial data indicated that the grain was considered dead ripe in Finland at moisture contents between 17 and 22.7% while similar figures for the Portuguese trials were 12 and 14%. However, when D was related to $\ln x_o/x_f$. 1/P (with x_o = 90% and x_f estimated at dead ripeness for the 63 trials), the correlation coefficient was +0.749. This slight decrease is a disappointing result which may be explained by the approximate nature of the x_f values, which had to be estimated in the absence of precise observations.

The ripening discrepancies for Finland and Portugal could be related to daylength. Data given by Nuttonson of barley ripening at places between 60° and 64°N in Alaska, Canada, Europe and Siberia also show remarkably rapid ripening. If the effect of daylength is upon gibberellin synthesis then the grain filling time must be considered as the appropriate stage. Daylength as used here is the period between sunrise and sunset plus the two periods of civil twilight. This was done because hormones are affected by quite low light intensities.

The multiple linear correlation between N (the average duration of daylight plus twilight during grain filling), 1/P (during grain drying) and D is +0.933. The regression equation is,

$$D = 123.5.\ \frac{1}{P} - 3.64N + 70.3 \qquad (2)$$

The mean error of estimate for D is 4.3 days. Although considerable improvements in estimates of D for Finland are made by equation (2), the situation for Holland and Belgium, in particular, is worse. This may indicate that a non linear term in N may be more appropriate.

Other Factors

Several other factors which are known to affect ripening were examined, but no satisfactory relations could be found.

Rain days

Equation (1) is strictly applicable when no rain falls during the drying. Falls of rain during the drying period would be expected to delay combining. The number of days with rain (ie $\geqslant$ 0.2 mm) were given in the trial data or were estimated from Daily Weather Reports for UK and France. Nothing conclusive was

found, and often the barley was considered dead ripe a few hours after some rain which was usually associated with a cold front.

Straw moisture content may be more important than grain moisture content when assessing the fitness to combine. Experimental work (Brück and Van Elderen 1969) shows that the straw moisture is subject to rapid fluctuations once the initial moisture content has dropped to a low level.

Soil Moisture Deficits

The deficit was estimated at ear emergence and at the end of grain filling for the 63 trials. Field capacity was assumed to hold at the end of a rainy spell in late winter. This is reasonable for northern Europe, but less so for Spain/ Portugal, however the soil in the root zone should be at capacity for the latter countries. There was a tendency for early ripening to be associated with high SMD, but glaring exceptions also occurred.

Phosphorous Fertilizer

High applications of phosphorous fertilizer are often reported to hasten leaf death and to speed up ripening. The amount of applied phosphorous was available for most trials, but no relationship was found even when the time of application and leaching were considered.

Soil pH

The uptake of phosphorous is known to be greatest when the pH of the soil is about 6. This could be important for Finland (rapid ripening) since for these trials the pH was between 5.7 and 6.6, while most other trials were grown in soils with pH greater than 7.

Any comments or criticisms should be sent direct to the author.

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